Docket No. 50-245
B11907

Millstone Nuclear Power Station
Unit No. 1
1985 IGSCC Program

December, 1985

Table of Contents

Section 1

Abstract

Millstone Unit No. 1

1985 IGSCC Program

Abstract

During the 1985 refueling outage, a comprehensive program addressing Intergranular Stress Corrosion Cracking (IGSCC) was implemented at Millstone Nuclear Power Station, Unit No. 1. This program included:

- a thorough inspection of susceptible welds,
- weld overlay repairs for six welds
  - 5 in the Jet pump Instrumentation Nozzle Assemblies
  - 1 in the Isolation Condenser
- Re-inspection of weld RCAJ-1

The details of each of these items are included in the following sections.

Section 2

Inspection Program and Results

Description of the IGSCC Inspection Program

During the Millstone Unit No. 1 1985 refueling outage, a total of 115 stainless steel welds were ultrasonically examined. In accordance with recommendations from the Staff[1], the 4" recirculation system weldolets which were not examined in 1984 were examined this outage and all were found to be acceptable. As shown in Table I, of the 115 welds examined, six (6) welds were found to be rejectable by examination. Table II contains a description of the flaws found in the six (6) welds and the dispositions of each. All examinations were conducted based on the guidance of NUREG-1061.

Ultrasonic examinations for IGSCC were performed by EBASCO, Trutom, Nuclear Energy Services (NES) and Northeast Utilities Service Company (NUSCO) personnel. Attachment 2 lists the name, company affiliation and requalification date for the ultrasonic examination personnel used to carry out the inspection program. All ultrasonic examination personnel were requalified for IGSCC detection at the EPRI NDE Center in accordance with suggestions provided by the NRC[2] prior to performing ultrasonic examinations during the refuel outage. Additionally, ultrasonic examination technicians were given procedure training, master/slave system training, as well as written and practical examinations as part of NU the on-site qualification for IGSCC examination. Samples containing actual IGSCC are used for the practical portion of the on-site qualification exercise.

Preliminary manual ultrasonic examination results which contained suspected IGSCC indications were provided to NUSCO for further evaluation and confirmation of results. NUSCO evaluations consisted of a four step program consisting of:

(1) Analysis of the reported data
(2) Review of radiographs for I.D. geometry
(3) Comparison of data to previous examination results
(4) Weld re-examination using alternative techniques, including:

- o I.D. creeping wave
- o 1.5 MHz, 4MHz, 55°L5MHz transducers etc.
- o Ultrasonic Data Recording and Processing System (UDRPs) (*Where the welds were adequately accessible for the equipment)

If a disposition was not obtained via the use of the above listed methods, radiography and I.D. penetrant examinations were performed. Such was the case for several welds in the LPCI system.

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(1) D. M. Crutchfield letter to J. F. Opeka, "Reinspection, Analyses and Repairs of the Reactor Coolant System Piping," dated June 26, 1984.

(2) J. A. Zwolinski letter to J. F. Opeka, "Piping Inspection Plan Millstone Nuclear Power Station, Unit No. 1," dated August 14, 1985.

Ten percent of the welds were examined using the master/slave system. The system was also used for several re-examinations of suspect welds by NUSCO personnel.

The final disposition of all weld indications was made by qualified NUSCO NDE personnel based on the additional information obtained during the evaluation program and the initial results provided by the qualified examination technicians. The final disposition and evaluation results are filed with the examination records for each weld.

Results of IGSCC Inspections
October/November 1985 Outage
Millstone Unit 1

Piping Systems	Inspected	Rejected	Repair
Recirculation	18	0	
Shutdown Cooling	4	0	
LPCI	51	0	
RWCU	8	0	
Core Spray	4	0	
Isolation Condenser	13	1	Weld Overlay
Weld Overlays	7	0	
Jet Pump Instrumentation Nozzle Assembly	10	5	Weld Overlay
Total	115	6	6 Weld Overlays

TABLE 1

Table II

Flaw Description and Disposition of Welds Rejected by Examination

System	Weld	Flaws	Disposition
Isolation Condenser	ICAC-F-13	#1) .22" deep x 2.5" long at 37"-39.5" clockwise. #2 and #3 of lesser depth. All flaws located in 8" length at 36"-3 7/8" Clockwise thru the 0 reference point at Top Dead Center of pipe.	Weld Overlay
Jet Pump Instrument Nozzle "A"	JPAF-2-SE	#1) .042" deep x .5" long at 5.5"-6" Clockwise. Note: Conservatively treated as a flaw. Examination was from Safe End side of weld only due to outside diameter geometric configuration.	Weld Overlay
	JPAJ-2	#1 and #2 both flaws combined are .1" deep x 4.66" long at 39"-3.22" Clockwise thru the 0 reference point at Top Dead Center of the JPI nozzle.	Weld Overlay
Jet Pump Instrument Nozzle "B"	JPBF-2-SE	#1) .09" deep x .5" long at 2.75"-3.25" Clockwise. Recorded by examiner at center point 3" Clockwise 1/2" long. #2) .06" deep x .625" long at 13.68"-14.31" Clockwise. Recorded by examiner at center point 14" Clockwise 5/8" long. Note: Conservatively treated as two flaws. Examination was from Safe End side of weld only due to outside diameter geometric configuration.	Weld Overlay

Table II

Flaw Description and Disposition of Welds Rejected by Examination

System	Weld	Flaws	Disposition
Jet Pump Instrument Nozzle "B"	JPBJ-2	#1) .172" deep x 360° intermittent. Recorded by examiner as 25% deep of .688" nominal wall thickness.	Weld Overlay
	JPBJ-3	#1) .344" maximum depth x 360° intermittent. Recorded by examiner as 50% maximum depth of .688" nominal wall thickness.	Weld Overlay
Recirculation	RCAJ-1	#1) .090" deep x 2 1/2" long at 0°. #2) .175" deep x 6 1/2" long at 23" Counter Clockwise. Note: Flaws match previous examination data from the 1984 outage. No change or new indications have been identified.	Accepted by Analysis in 1984

SECTION 3

WELD OVERLAYS

Table III

Millstone Unit No. 1

ISI/NDE STATUS REPORT

System		Welds Scheduled	Welds Acceptable	Welds Rejectable	Comments
28" RECIRC		3	3	0	Complete
22" RECIRC		1	1	0	Complete
18" LPCI		46	46	0	Complete
16"	LPCI	5	5	0	Complete
	ISO COND	1	1	0	Complete
	S.D. CLG	1	1	0	Complete
14"	S.D. CLG	1	1	0	Complete
	ISO CAP	1	1	0	Complete
12"	RECIRC	4	4	0	Complete
	ISO COND	7	6	1	Complete*
	S.D. CLG	2	2	0	Complete
10"	CORE SPRAY	4	4	0	Complete
	ISO COND	4	4	0	Complete
8"	CLEAN-UP	8	8	0	Complete
WELD OVERLAYS		13	13	0	Complete**
4" RECIRC BYP		5	5	0	Complete
JET PUMP INSTR		10	5	5	Complete
RECIRC SAFE ENDS		4	4	0	Complete
RCAJ-1 (UDRPS)		1	1	0	Complete
TOTAL		121	115	6	

* The examination scope was increased by four welds from the original inspection plan due to the rejection of weld ICAC-F-13.

** The examination scope was increased by six weld overlays from the original inspection plan due to the addition of welds ICAC-F-13, JPAF-2, JPAJ-2, JPBF-2, JPBJ-2 and JPBJ-3, which were found to be rejectable during the 1985 inspection.

Weld Categories per NUREG-1061

Category "A": Resistant material welds and welds of non-resistant to resistant material that were corrosion resistant clad welded (CRC).

Requirement: 5% by pipe size inspected each outage

Category "B": Non-resistant material welds with IHSI applied and welds of non-resistant to resistant material that were heat sink welded (HSW).

Requirement: 10% by pipe size each outage

Category "C": Non-resistant material

Requirement: 25% by pipe size each outage and all welds that were not inspected to IEB 82-03 and 83-02 inspection requirements this outage.

Category "S": Supplemental inspections required by NUSCO.

Category "AA": Additional Category "A" LPCI System welds, inspected beyond the minimum requirements of NUREG-1061.

Category "AC": Additional Category "C" LPCI system welds inspected beyond the minimum requirements of NUREG-1061.

SYSTEM: LPCI "A" Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
CCAJ-17	C	18"	X	
CCAJ-18	C	18"	X	
CCAJ-19	C	18"	X	
CCAJ-20	C	18"	X	
CCAJ-21	C	18"	X	
CCAJ-23	S	18"	X	
CCAJ-24	S	18"	X	
CCAJ-25	S	18"	X	
CCAJ-26	S	18"	X	

SYSTEM: LPCI "B" Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
CCBJ-16	C	18"	X	
CCBJ-17	C	18"	X	
CCBJ-18	C	18"	X	
CCBJ-19	C	18"	X	
CCBJ-20	C	18"	X	
CCBJ-21	S	18"	X	
CCBJ-22	S	18"	X	
CCBJ-22A	S	18"	X	
CCBJ-22B	S	18"	X	
CCBJ-23	S	18"	X	
CCBJ-24	S	18"	X	
CCBJ-25	S	18"	X	
CCBJ-26	S	18"	X	
CCBJ-27	S	18"	X	
CCBJ-SC-1	S	12"	X	

SYSTEM: LPCI "A" Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
CCAJ-3	C	18"	X	
CCAJ-4	C	18"	X	
CCAJ-5	C	18"	X	
CCAJ-6	C	18"	X	
CCAJ-7	C	18"	X	
CCAJ-8	C	18"	X	
CCAJ-9	C	18"	X	
CCAJ-10	C	16"	X	
CCAJ-11	C	16"	X	
CCAJ-12	C	18"	X	
CCAJ-13	C	18"	X	
CCAJ-14	C	18"	X	
CCAJ-15	C	18"	X	
CCAJ-16	C	18"	X	
CCAJ-2	AC	18"	X	

SYSTEM: LPCI "B" Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
CCBJ-5	AC	16"	X	
CCBJ-6	A	16"	X	
CCBJ-9	AA	16"	X	
CCBJ-1	AC	18"	X	
CCBJ-2	AC	18"	X	
CCBJ-3	AC	18"	X	
CCBJ-4	AC	18"	X	
CCBJ-10	C	18"	X	
CCBJ-11	C	18"	X	
CCBJ-12	C	18"	X	
CCBJ-13	C	18"	X	
CCBJ-14	AC	18"	X	
CCBJ-15	AC	18"	X	

SYSTEM: Clean Up Supply Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
CUAJ-2	A	8"	X	
CUAJ-4	C	8"	X	
CUAJ-5	C	8"	X	
CUAJ-6	C	8"	X	
CUAJ-7	C	8"	X	
CUAJ-7A	B	8"	X	

SYSTEM: Shutdown Cooling Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
SCCF-1	S	12"	X	

SYSTEM: Shutdown Cooling Header "A"

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
SCAJ-1	A	14"	X	

SYSTEM: Recirc Bypass Weldolet and Cap

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
RCAJ-PB-1	S	4" weldolet	X	
RCAJ-PB-2	S	4" weldolet	X	
RCBJ-PB-1	S	4" weldolet	X	
RCBJ-PB-2	S	4" weldolet	X	
RCAJ-30	A	4" CAP	X	

SYSTEM: Core Spray Header "B"

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
CSBJ-13A	B	10"	X	
CSBJ-14	C	10"	X	
CSBJ-15	C	10"	X	
CSBJ-16	C	10"	X	

SYSTEM: Clean Up Return Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
CUBJ-18	C	8"	X	
CUBJ-19	C	8"	X	

SYSTEM: Isolation Condenser Piping

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
ICAC-F-13	C	12"		X
ICAC-F-14	C	12"	X	
ICAC-F-16A	A	12"	X	
ICAC-F-8	C	16"	X	
*ICAC-F-15	C	12"	X	
*ICAC-F-16	C	12"	X	
*ICAC-F-12	C	12"	X	
*ICAC-F-12A	C	12"	X	

*Additional welds required to be inspected due to rejectable indication in ICAC-F-13.

SYSTEM: Isolation Condenser Return Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
ICBJ-5	C	10"	X	
ICBJ-6	C	10"	X	
ICBJ-7	C	10"	X	
ICBJ-8	A	10"	X	

SYSTEM: Recirc Risers

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
RRCJ-1	B	12"	X	
RRCJ-2	B	12"	X	
RRCJ-4	B	12"	X	
RRFJ-3	B	12"	X	

SYSTEM: Recirc System Discharge Header "A"

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
RMAJ-4	B	22"	X	
RMAJ-RRC	B	28"	X	

SYSTEM: Recirc System

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
RCAJ-1	C	28"	X	
RCAJ-SC-1	B	16"	X	
RCAJ-1A	B	28"	X	
RCAJ-2	B	28"	X	

SYSTEM: Jet Pump Instrumentation Nozzle "A" and "B"

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
JPAF-1	S	5"	X	
JPAF-2	S	4"		X
JPAJ-1	S	8"	X	
JPAJ-2	S	12"		X
JPAJ-3	S	12"	X	
JPBF-1	S	5"	X	
JPBF-2	S	4"		X
JPBJ-1	S	8"	X	
JPBJ-2	S	12"		X
JPBJ-3	S	12"		X

SYSTEM: Recirc Riser Safe Ends

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
RRCF-1	S	12"	X	
RREF-1	S	12"	X	
RRFF-1	S	12"	X	
RRGF-1	S	12"	X	

SYSTEM: Recirc System Weld Overlays

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
RRAJ-4	S	12"	X	
RRBJ-1	S	12"	X	
RRBJ-2	S	12"	X	
RRCJ-3	S	12"	X	
RREJ-3	S	12"	X	
RRFJ-1	S	12"	X	

SYSTEM: Isolation Condenser Supply Header

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
ICBJ-CAP	AC	14"	X	

SYSTEM: Isolation Condenser Weld Overlays

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
ICAC-F-3	S	16"	X	
*ICAC-F-13	S	12"	X	

SYSTEM: Jet Pump Instrumentation Nozzles A&B Weld Overlays

Weld Designation	Category	Pipe Diameter	Acceptable	Rejectable
*JPAF-2	S	4"	X	
*JPAJ-2	S	12"	X	
*JPBF-2	S	4"	X	
*JPBJ-2	S	12"	X	
*JPBJ-3	S	12"	X	

*overlays applied during 1985 refuel outage

Millstone Unit No. 1
1985 IGSCC Program
Weld Overlay Design
and Implementation

Scope:

Weld overlays were applied to six (6) weld joints; one (1) on the Isolation Condenser Piping System and five (5) on the Jet Pump Instrumentation Nozzle Assemblies. The listing of welds and overlay designs implemented appear in Table I.

Design:

The design of the weld overlays used for Millstone Unit No. 1 during the 1985 refueling outage was accomplished using the computer program PC-CRACK, developed by Structural Integrity Associates. Inputs into the program are: the source equations for ASME Section XI Table IWB-3641-1 with the stress ratio,

$$\frac{P_m + P_b}{Sm}$$

for the unrepaired joint; the pipe wall thickness; and a factor of safety (2.773 was used in all cases).

Using these inputs, the program calculates the weld overlay thickness for through-wall cracks in the unrepaired pipe using an iteration containing these steps:

(1) Calculate the allowable a/t using the source equations (including the factor of safety) for the given stress ratio.

(2) Assume an applied weld overlay of arbitrary thickness t.

(3) Reduce the stress ratio in proportion to the increase in wall thickness resulting from the applied overlay (Note: The pipe wall thickness becomes (t + t) with the application of the overlay).

(4) Recalculate the allowable a/t corresponding to the adjusted stress ratio.

If the calculated a/t from step (4) is larger than the allowable value determined in step (1), steps (2) through (4) are repeated (the weld overlay thickness is increased) until the solution converges to the allowable a/t for the adjusted stress level.

All weld overlays (six) designed during the 1985 MP1 outage were full structural weld overlays, which are based on an assumed 100% through wall, 360° around the pipe circumference postulated flaw.

Implementation:

The weld overlays were applied by GAPCO. Initial overlay layers that did not pass PT examination and did not exhibit a delta ferrite measurement greater than 8FN were not included in the final design overlay thickness. All overlays were deposited using the automatic GTAW process utilizing ER308L/ERNiCr-3 weld wire depending on the base metal to be overlayed.

Materials:

All weld filler metal met the following specifications as applicable.

Weld Wire	Specification
ER 308L	ASME, Section II, Part C, SFA5.7, Maximum carbon content .015% and a delta ferrite level of 11FN.
ERNiCr-3	ASME, Section II, Part C, SFA5.14.

Inspection:

All weld overlays were subjected to a liquid penetrant inspection of the first layer that exhibited a delta ferrite level greater than 8FN and the final layer. Angled beam longitudinal wave techniques were used for detection and sizing of flaws in the overlay and required base material. Zero degree longitudinal wave examinations are performed on new overlays to detect lack of bonding or clustered small flaws in the overlay and at the base material interface. All examinations are performed manually by EPRI qualified individuals using EPRI suggested techniques.

TABLE IV
WELD OVERLAY DESIGN

Weld Designation/Pipe Size	$\frac{P_m + P_b}{S_m}$	Overlay Design	Bounding Flaw Size
ICAC-F-13 12" .68" wall	1.0	$t_{overlay}$ = 0.43" $L_{overlay}$ = 4.2"	a/t = 1.0 L = 360°
JPBJ-3 12" .68" wall	0.35	$t_{overlay}$ = 0.2" $L_{overlay}$ = 4.2"	a/t = 1.0 L = 360°
JPBJ-2 12" .68" wall	0.36	$t_{overlay}$ = 0.2" $L_{overlay}$ = 4.2"	a/t = 1.0 L = 360°
JPBF-2 4" .377" wall	0.46	$t_{overlay}$ = 0.12" $L_{overlay}$ = 4.0	a/t = 1.0 L = 360°
JPAJ-2 12" .68" wall	0.37	$t_{overlay}$ = 0.2" $L_{overlay}$ = 4.2"	a/t = 1.0 L - 360°
JPAF-2 4" .337" wall	0.52	$t_{overlay}$ = 0.12" $L_{overlay}$ = 4.0"	a/t = 1.0 L = 360°

SECTION 4

SUMMARY AND CONCLUSIONS

Summary and Conclusions

The 1985 IGSCC program exceeds the provisions of the ASME Boiler and Pressure Vessel Code and the guidelines of NUREG-1061. This is true since the percentages of welds, per pipe size, inspected meet or exceed NUREG-1061 guidelines. Also, the thorough inspection program using recently requalified inspection personnel and equipment (including ultrasonic imaging and "master/slave" scanning) give a high degree of confidence that the welds inspected do not contain IGSCC. Further, where IGSCC has been mitigated by weld overlays, the design implementation and inspection procedures result in a safe weld joint.

In view of these facts, Northeast Utilities has concluded that no unreviewed safety questions currently exist with respect to IGSCC at Millstone Unit No. 1.

Finally, the flawed joint accepted by analysis (RCAJ-1) and treated by Induction Heating Stress Improvement (IHSI) in 1984 showed no evidence of crack growth. This result serves to assure the validity of the conclusions in the original analysis, thereby providing justification for operation for another refuel cycle.

Section 5

Information Requested During 12/3/85
Meeting between NUSCO and the NRC

Additional Information
Requested by the Nuclear Regulatory Commission

Item #1

NRC Request: Provide weld designations of the welds that received IHSI last refuel outage.

Response: See Attachment #1

Item #2

NRC Request: Provide the names of UT inspectors that were requalified at EPRI for IGSCC and the dates they requalified.

Response: See Attachment #2

Item #3

NRC Request : Provide a sketch of the Inconel weld overlay design.

Response: See Attachment #3

Item #4

NRC Request: Provide thickness measurements of the weld overlays and basemetal thicknesses.

Response: See Attachment #4 for weld overlay thicknesses and Section 3, Table I for basemetal thicknesses.

Item #5

NRC Request: How many IGSCC susceptible welds were not inspected over the last two refuel outages.

Response: Seven (7) inaccessible inner diameter butt welds have not been inspected. The welds are part of flued-head penetration assemblies located on the Reactor Water Clean-up System (2); Low Pressure Coolant Injection (2); Core Spray (1); Isolation Condenser (2) piping systems. One of the two core spray inaccessible welds was PT examined from the I.D. when made accessible during last year's core spray piping replacement, and found to be free of defects.

Item #6

NRC Request: Last refuel outages SER identified eight (8) IGSCC susceptible welds on the 4" recirculation bypass caps that were not inspected. Why were only 5 welds expected this outage?

Response: There are only 4 IGSCC susceptible welds on the 4" bypass lines. These are the weldolet to pipe welds which were inspected and found acceptable (see Section 2). The other 4 welds are corrosion-resistant cladded weldolet to cap welds and are not susceptible to IGSCC. These have been classified category 'A' welds per NUREG-1061, as presented to the NRC, in our submittal on July 1, 1985. Per NUREG-1061 only 5% of these welds (category A) required inspection, therefore only one of the four bypass cap welds was inspected this year and found acceptable.

<u>Item #7</u>

NRC Request: Provide delta ferrite measurements for all stainless steel weld overlays applied this refuel outage.

Response: See Attachment #5.

Attachment #1

WELDS TREATED BY INDUCTION HEATING STRESS IMPROVEMENT

RCAJ-1*	RMAJ-4	RCBJ-10
RCAJ-1A	RMAJ-RRC	RCBJ-11
RCAJ-2	RMAJ-2	RCBJ-12
RCAJ-3	RMAJ-3	RCBJ-13
RCAJ-SC-1	RRAJ-1 through 3	RCBJ-14
RCAJ-4	RRBJ-1 through 4	RCBJ-CC-1
RCAJ-5	RRCJ-1 through 4	RCBJ-15
RCAJ-6	RRDJ-1 through 4	RCBJ-16
RCAJ-7	RREJ-1, 2, 4	RMBJ-3
RCAJ-8	RCBJ-1	RMBJ-2
RCAJ-10	RCBJ-1A	RMBJ-4
RCAJ-11	RCBJ-2	RMBJ-RRH
RCAJ-12	RCBJ-3	RMBJ-5
RCAJ-13		RMBJ-1
RCAJ-14	RCBJ-4	RRFJ-2 through 4
CCAJ-1	RCBJ-5	RRGJ-1 through 4
RCAJ-15	RCBJ-6	RRHJ-1 through 4
RMAJ-1	RCBJ-7	RRJJ-1 through 4
RMAJ-5	RCBJ-8	RRKJ-1 through 4

NOTE: RCAJ-9 and RCBJ-9 are not susceptible to IGSCC and, therefore were not treated.

*contains flaw.

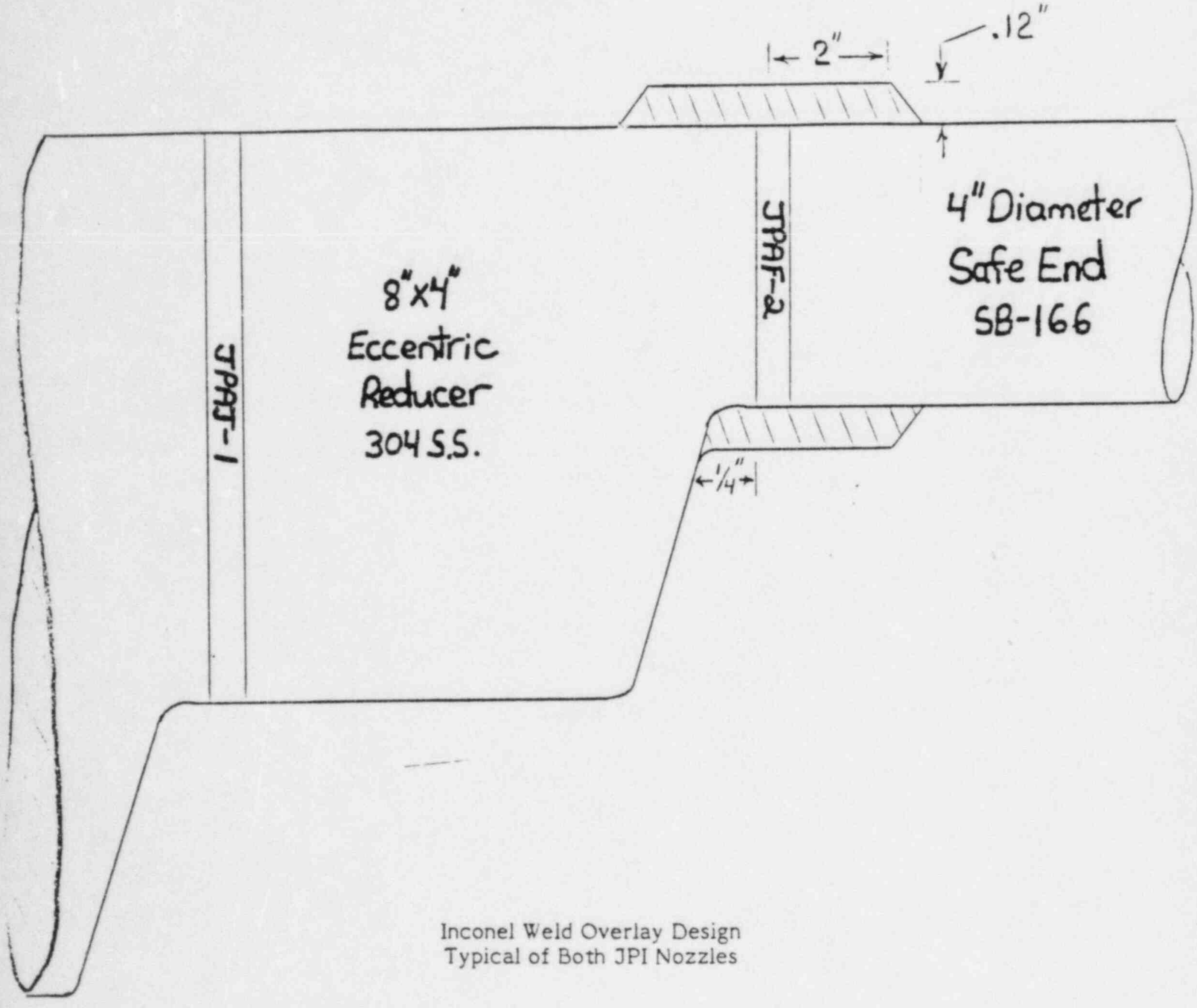
Attachment #2

Personnel Requalified by EPRI
for Detection of IGSCC

Name	Company	Date Requalified
Charles Pattillo	Ebasco	Sept. 17, 1985
Dan Nowakowski	Ebasco	Sept. 10, 1985
Tom Pederson	Ebasco	Sept. 17, 1985
Roger Soriano	Trutom	Sept. 24, 1985
Rick Pfannenstiel	Trutom	Sept. 27, 1985
Robert Bouck	Ebasco	Sept. 10, 1985
Peter Durand	NUSCO	Oct. 11, 1985
Steve Sikorski	NUSCO	Sept. 24, 1985
Neal MacNamara	NES	Nov. 5, 1985

Attachment #3

Jet Pump Instrumentation
Nozzle Assembly Inconel Weld
Overlay Design



Inconel Weld Overlay Design
Typical of Both JPI Nozzles

Attachment #4

WELD OVERLAY THICKNESSES*

WELD NO. (WOL Design Thickness)		FIRST LAYER (>8FN)			FINAL LAYER			LAYER THICKNESS		
		A	B	C	A	B	C	A	B	C
	0°	.910	.881	.860	1.403	1.408	1.324	.493	.527	.464
ICAC-F-13	90°	.910	.992	.865	1.399	1.505	1.355	.489	.513	.490
(.430)	180°	.893	.926	.942	1.401	1.448	1.465	.508	.522	.523
	270°	.910	1.012	.956	1.408	1.535	1.443	.498	.523	.487
	0°	1.470	.800	.820	1.670	1.080	1.090	.200	.280	.270
JPBJ-3	90°	1.430	.820	.830	1.670	1.080	1.100	.240	.260	.270
(.200)	180°	1.500	.820	.830	1.710	1.120	1.110	.210	.300	.280
	270°	1.430	.840	.840	1.710	1.090	1.100	.280	.250	.260
	0°	.800	.840	.770	1.030	1.070	1.020	.230	.230	.250
JPAJ-2	90°	.850	.800	.780	1.060	1.050	1.030	.210	.250	.250
(.200)	180°	.810	.810	.780	1.060	1.050	1.050	.250	.240	.270
	270°	.810	.840	.780	1.020	1.060	1.030	.210	.220	.250
	0°	.420	.380	.380						
JPAF-2	90°	.410	.370	.390						
(.120)	180°	.460	.370	.390						
Inconel 82	270°	.450	.460	.460						
	0°	.900	.920	.840	1.130	1.130	1.110	.230	.210	.270
JPBJ-2	90°	.900	.930	.860	1.190	1.220	1.130	.290	.290	.270
(.200)	180°	.920	.930	.890	1.250	1.270	1.220	.330	.340	.330
	270°	.880	.890	.860	1.110	1.170	1.190	.230	.280	.330
	0°	.773	.475	.665						
JPBF-2	90°	.323	.424	.409						
(.120)	180°	.326	.418	.391						
Inconel 82	270°	.317	.364	.417						

*all measurements in inches

Attachment #5

Weld Overlay Delta Ferrite Measurements

Weld	Layer	Delta Ferrite Level	
JPAJ-2			
8FN was reached on 1st layer	1	8 FN	
3 additional layers	2	10.8 FN	9.97 average
	3	11.1 FN	
JPBJ-2			
8FN achieved on 2nd layer	2	8 FN	
4 additional layers	3	10.8 FN	
	4	10.5 FN	10.6 average
	5	12 FN	
	6	12 FN	
ICAC-F-13			
8FN achieved on 2nd layer	2	9.3 FN	
7 additional layers	3	10.0 FN	
	4	10.5 FN	
	5	10.4 FN	10.4 average
	6	10.9 FN	
	7	11.3 FN	
	8	10.4 FN	
JPBJ-3			
8FN achieved on 1st layer	1	8 FN	
4 additional layers	2	10 FN	
	3	10.6 FN	9.8 average
	4	10.4	
	5	10 FN	